Quadrant II – Transcript and Related Materials

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Name of the Presenter: Ms. Vinita Q. D'Sa

Notes

RESPIRATORY PIGMENTS

Introduction

In unicellular animals, the respiratory gases are directly diffused into or outside the cell. In complex multicellular animals, these gases are transported to different parts of the body with the help of circulatory system. Blood is a circulatory fluid which contains a respiratory pigment that acts as the carrier of the respiratory gases. The nature of respiratory pigment varies in different animals.

Respiratory pigments differ in their chemical constitution in different group of animals and even in the same phylum, there may be several types of pigments.

These pigments include the cytochromes, the flavoproteins and other coloured protein molecules called "chromoproteins".

What is a respiratory pigment?

A respiratory pigment is a molecule such as haemoglobin, that increases the oxygen carrying capacity of the blood.

Respiratory pigment is a circulating pigment which mediates transfer of respiratory gases at the extracellular and intracellular levels.

Characteristics

Respiratory pigments are chromoproteins that contain a metallic element in their constitution.

They have special affinities for respiratory gases.

They are distributed either in the blood corpuscles, blood plasma or body fluids.

They combine reversibly with the respiratory gases and play a key role in their transportation.

In general, respiratory pigments are coloured proteins that contain a metallic element in their constitution and have the property of combining with oxygen and sometimes with carbon dioxide.

Four biochemically different respiratory pigments are recognized – haemoglobin, chlorocruorin, hemocyanin, and hemerythrin. Even in the same phylum there may be several distinct pigments, and more than one distribution of four pigments in the animal pigment may exist in the same animal.

Haemoglobin:

It is widely distributed in the animal kingdom, starting from some protozoa like Paramecium to almost all vertebrates except eel larvae and some Antarctic fishes. Some invertebrate phyla viz., Porifera, Cnidaria and Ctenophora, totally lack it. It is found in the dissolved condition in the plasma of the blood of molluscs, annelids and arthropods but in the red blood corpuscles in chordates. It is found in the body fluids of some protozoans. Also found in the muscles of birds and mammals and is known as myoglobin.

Haemoglobin is made up of an iron porphyrin compound, haeme, associated with a protein, globin. Haeme is a metalloporphyrin. It is composed of four pyrrole rings linked by methenyl bridges to form a super-ring with an atom of ferrous iron in the centre attached to the pyrrole nitrogens. The cyclic tetrapyrrole structure is a **porphyrin**. Porphyrins appeared early in biopoiesis and assumed critical roles in photosynthesis, in enzymes, in electron transport, in gas transport and in many pigments. Metabolically, the most important of the porphyrins are the Metalloporphyrins, with an atom of metal chelated between four pyrrole nitrogen atoms. Haeme with its atom of ferrous iron and chlorophyll with magnesium are familiar examples. The haeme component is a constant structural feature of all haemoglobin, but the globin portion varies in different species. In addition, varying numbers of haemoglobin units unite to form polymers of different sizes.

The different haemoglobins vary in oxygen combining capacities. This variation in oxygen capacity is a property of the total molecule and does not depend upon structural differences or changes in the metalloporphyrin component. In all cases, the atom of ferrous iron (haeme unit) is associated with one molecule of oxygen to form oxyhaemoglobin. The reaction is readily reversible; the unoxygenated compound is referred to as deoxyhaemoglobin or less accurately as reduced haemoglobin.

Since all proteins are species-specific, it is not surprising that the haemoglobin molecule differs in various animals. The situation, however is more complex. Several forms of haemoglobin are regularly found within the same animal. Two or three haemoglobins have been described in molluscs and echinoderms while six to nine were reported in the insect Chironomus. Multiple haemoglobins are characteristic of all of the vertebrates. Further, there may be a succession of haemoglobins during development, with each type adapted to the respiratory needs of the particular stage of development. In man, there are four different peptide chains in the vascular haemoglobins with the relative amounts of each characteristic of the stage of development. In the adult human, 90% consists of 2 alpha chains combined with 2 beta chains to form single tetrameric molecule (called Haemoglobin A). There are 141 amino acids in an α-peptide chain, while each β-chain contains 146. When the two chains are places side by side, 64 of the amino acids are common to both. Several additional types of human hemoglobin may arise through mutation. Small changes in the protein molecule may greatly alter its physiology. The difference between normal and sickle-cell hemoglobin is a difference in only one of the amino acids of the peptide chain and depends on the presence of a single mutant gene.
The percentage of haemoglobin in the blood varies from animal to animal. In the human blood, every 20 ml of blood approximately contains 10 gms of haemoglobin. In human being, each gram of haemoglobin can combine with about 1.39 ml of oxygen.

Chlorocruorin - this green iron containing pigment is also a metallo-porphyrin which is closely related to haemoglobin and cytochromes. This pigment is found in dissolved condition in plasma only and its distribution is restricted to four families of polychaeta (Annelida): Sabellidae, Serpulidae, Chlorohaemidae and

Ampharetidae. The oxygen combining capacity of chlorocruorin is comparable to that of haemoglobin.

This pigment was discovered by Milne- Edwards in Polychaetes in the year 1838. Its respiratory properties have been studied by Lankester and according to him, the pigment occurs in two forms, one oxidised and the other reduced.

Hemerythrin: This violet-coloured iron containing chromoprotein was first discovered in the ancient brachiopod, ***Lingula*** and is evidently confined to a small number of marine invertebrates: most sipunculids, two priapulids (***Priapulus*** and ***Halicryptus***), two brachiopods (Lingula and Glottidia) and **one** polychaete, ***Magelona.*** These are all unrelated phyla and bear no phylogenetic relationships**.** Like the low molecular weight haemoglobins, it is found only in the blood cells and occurs only in multiple forms. It is less efficient in its oxygen carrying capacity when compared with haemoglobin.

Haemocyanin: is of wide occurrence and is a non- haeme respiratory pigment. It is dispersed in the plasma solution and has never been found in the corpuscles. Although present in many animal species, its distribution is limited to representatives of only two phyla: the Mollusca (all except the bivalves and opisthobranch gastropods) and the Arthropoda (most of the crustaceans and some of the chelicerates). The metallic atom present in the haemocyanin molecule is copper which gives it a characteristic blue colour. It occurs in two forms, oxidised and reduced and the crystals of the latter are prism-shaped or needle-shaped which are soluble in water.

In addition to the above-mentioned pigments, there are certain other miscellaneous pigments which are sporadically met in the animals. These are **Pinnaglobin** -manganese containing brown pigment, **Echinochrome-**, red pigment in the body fluid of sea urchin, **Vanadium**- respiratory pigment in the body of ascidians and **Molpadin** -in holothurians.